THE CLAIMED INVENTION IS:

[C1] A method of forming inertia friction welds that results in work parts welded with a specified angular orientation with respect to each other, comprising:

loading a sample work part into a rotating chuck attached to a spindle and loading another sample work part into a non-rotating chuck;

applying torque to the spindle to accelerate the spindle to achieve a predetermined first rotational speed;

coasting the spindle to achieve a predetermined second rotational speed;

inertia friction welding together the sample work parts to form a sample weld;

measuring and storing data related to the deceleration of the spindle during the sample inertia friction weld;

removing the welded sample work parts from the rotating and the non-rotating chucks;

calculating a sample deceleration profile of the spindle from the data acquired during the formation of the sample weld;

loading a production work part into the rotating chuck and loading another production work part into the non-rotating chuck;

applying torque to the spindle to accelerate the spindle to the predetermined first rotational speed;

maintaining the predetermined first rotational speed until a rotary position of the spindle matches a calculated value;

inertia friction welding together the production work parts to form a production weld; and

controlling torque applied to the spindle during the inertia friction welding of the production work parts so that the spindle deceleration during the formation of the production weld matches the sample deceleration profile of the spindle during the formation of the sample weld and so that the production weld ends in the specified angular orientation of the work parts with respect to each other.

[C2] The method of claim 1 further including applying torque to the spindle to maintain the predetermined first rotational speed of the spindle for a time period after the spindle has been accelerated to the predetermined first rotational speed and before coasting of the spindle and inertia friction welding together the sample work parts.

[C3] The method of claim 2 further including applying torque to the spindle to maintain the predetermined first rotational speed of the spindle for the time period after the spindle has been accelerated to the predetermined first rotational speed and before inertia friction welding together the production work parts.

[C4] The method of claim 2 further including removing torque after achieving the predetermined first rotational speed and before friction welding together the sample work parts.

[C5] The method of claim 1 further including transferring energy from the rotating spindle during the inertia friction welding of the sample piece and the other sample work piece.

[C6] The method of claim 5 wherein the spindle has a mass, the energy being stored by the rotating mass before being transferred by the spindle.

[C7] The method of claim 6 wherein the spindle includes a flywheel which provides additional mass.

[C8] The method of claim 1 wherein measuring and storing the data during formation of the sample weld comprises measuring a rotational speed of the spindle and a rotary position of the spindle during deceleration of the spindle.

[C9] The method of claim 1 wherein controlling torque results in rotating the spindle a same number of revolutions that the spindle rotates during formation of the sample weld.

[C10] The method of claim 9 wherein calculating the sample deceleration profile includes measuring a rotational speed of the spindle and a rotary position of the spindle as a function of time and wherein controlling the torque executes the same number of revolutions as a function of time during formation of the production weld.

[C11] The method of claim 1 wherein controlling torque produces a non-linear deceleration of the spindle during the formation of the production weld.

[C12] The method of claim 1 further comprising recording an end of acceleration time mark.

[C13] The method of claim 12 wherein the sample deceleration profile is calculated from the end of the acceleration time mark to a rest mark.

[C14] The method of claim 13 wherein calculating the sample deceleration profile includes measuring a rotational speed of the spindle and a rotary position of the spindle between the end of the acceleration time mark and the rest mark.

[C15] The method of claim 1 wherein the torque is applied to the spindle by a drive that includes a motor.

[C16] The method of claim 1 wherein during the inertia friction welding of the sample work parts and of the production work parts the non-rotating chuck is moved towards the spindle to initiate contact of the work parts.

[C17] The method of claim 16 wherein the non-rotating chuck is moved towards the spindle by a slide.

[C18] A method of forming inertia friction welds that results in work parts welded with a specified angular orientation, comprising:

(a) loading one of a pair of a sample work parts into a spindle and loading the other of the pair of sample work parts into a non-rotating chuck;

(b) applying torque to the spindle to accelerate the spindle to achieve a predetermined first rotational speed;

(c) coasting the spindle to achieve a predetermined second rotational speed;

(d) inertia friction welding together the pair of sample work parts to form a sample weld;

(e) calculating a sample deceleration profile of the spindle subsequent the formation of the sample weld;

(f) removing the welded-together pair of sample work parts from the spindle and the non-rotating chuck; and

(g) forming a plurality of production welds by:

(i) loading one of a pair of production work parts into the spindle and

loading the other of the pair of production work parts into the non-rotating chuck;

(ii) applying torque to the spindle to accelerate the spindle to the predetermined first rotational speed;

(iii) maintaining the predetermined first rotational speed until a rotary position of the spindle matches a calculated value;

(iv) inertia friction welding together the production work parts to form one of the plurality of production welds;

(v) controlling torque applied to the spindle during the inertia friction welding together of the production work parts so that the spindle deceleration during the formation of the production weld matches the sample deceleration profile of the spindle during the formation of the sample weld and so that the production weld ends in the specified angular orientation of the work parts with respect to each other;

(vi) removing the welded-together pair of production work parts from the spindle and non-rotating chuck; and

(vii) repeating (i) - (vi) above with other pairs of production work parts.

[C19] The method of claim 18 further including applying torque to the spindle to maintain the predetermined first rotational speed of the spindle for a time period after the spindle has been accelerated to the predetermined first rotational speed and before coasting of the spindle and inertia friction welding together the sample work parts.

[C20] The method of claim 19 further including applying torque to the spindle to maintain the predetermined first rotational speed of the spindle for the time period after the spindle has been accelerated to the predetermined first rotational speed and before inertia friction welding together each pair of production work parts.

[C21] The method of claim 19 further including removing torque after achieving the predetermined first rotational speed and before inertia friction welding together the sample work parts.

[C22] The method of claim 18 further including transferring energy from the rotating spindle during the inertia friction welding of the sample work piece and the other sample work piece.

[C23] The method of controlling of claim 22 wherein the spindle includes a flywheel.

[C24] The method of claim 18 further comprising measuring and storing data during formation of the sample weld by measuring a rotational speed of the spindle and a rotary position of the spindle during deceleration of the spindle.

[C25] The method of claim 18 wherein controlling torque results in rotating the spindle a same number of revolutions that the spindle rotates during formation of the sample weld.

[C26] The method of claim 25 wherein calculating the sample deceleration profile includes measuring a rotational speed of the spindle and a rotary position of the spindle as a function of time and wherein controlling the same number of revolutions as a function of time during formation of the production weld.

[C27] The method of claim 18 further comprising recording an end of acceleration time mark to obtain the predetermined first rotational speed, and wherein the sample deceleration profile is calculated from the end of the acceleration time mark to a rest mark.

[C28] The method of claim 27 wherein calculating the sample deceleration profile includes measuring a rotational speed of the spindle and a rotary position of the spindle between the end of the acceleration time mark and the rest mark.

[C29] A method of forming inertia friction welds that results in work parts welded with a specified angular orientation, comprising:

loading a sample work part into a spindle and loading another sample work part into a non-rotating chuck;

applying torque to the spindle to accelerate the spindle to achieve a predetermined first rotational speed;

coasting the spindle to a predetermined second rotational speed;

contacting together the sample work parts to inertia friction weld together the sample work parts and to form a sample weld, the spindle decelerating and transferring energy as it decelerates to create the sample weld;

measuring and storing data related to the deceleration of the spindle during the sample inertia friction weld;

calculating a sample deceleration profile from the data acquired during the formation of the sample weld by measuring a rotational speed of the spindle and a rotary position of the spindle during the deceleration of the spindle;

removing the welded-together sample work parts from the spindle and the non-rotating chuck;

loading a production work part into the spindle and loading another production work part into the non-rotating chuck;

applying a torque to the spindle to accelerate the spindle to achieve the predetermined first rotational speed;

maintaining the predetermined first rotational speed until a rotary position of the spindle matches a calculated value;

contacting together the production work parts to inertia friction weld together the production work parts and to form a production weld; and

controlling torque applied to the spindle during the inertia friction welding of the production work parts so that the spindle deceleration during the formation of the production weld matches the sample deceleration profile of the spindle during the formation of the sample weld and so that the production weld ends in the specified angular orientation of the work parts with respect to each other.

[C30] The method of claim 29 wherein the energy transferred from the spindle is stored by a rotating flywheel of the spindle.

[C31] The method of claim 29 further including applying torque to the spindle to maintain the predetermined first rotational speed of the spindle for a time period after the spindle has been accelerated to the predetermined first rotational speed and before initiating contact between the sample work parts, and applying torque to the spindle to maintain the predetermined first rotational speed of the spindle for the time period after the spindle has been accelerated to the predetermined first rotational speed and before initiating contact between the production work parts.

[C32] The method of claim 29 further including removing torque after achieving the predetermined first rotational speed and before inertia friction welding together the sample work parts.

[C33] The method of claim 29 wherein calculating the sample deceleration profile includes measuring a rotational speed of the spindle and a rotary position of the spindle as a function of time and wherein controlling the torque executes the same number of revolutions as a function of time during formation of the production weld.

[C34] The method of claim 29 wherein controlling torque produces a non-linear deceleration of the spindle during formation of the production weld.

[C35] The method of claim 29 wherein during the contacting of the sample work parts and of the production work parts the non-rotating chuck is moved towards the spindle to cause contact of the work parts by a slide associated with the non-rotating chuck.

[C36] An inertia friction weld system, comprising:

a spindle having a flywheel, the spindle being configured to engage one of a first pair of parts in a known orientation;

a drive operatively connected to the spindle to apply torque to the spindle to rotate the spindle;

a non-rotating chuck spaced from the spindle and configured to engage the other of the first pair of parts;

a slide configured to slide the non-rotating chuck toward the spindle to facilitate welding together of the first pair of parts;

a motion controller operatively connected to the drive, the motion controller being configured: to engage the drive to apply torque to the spindle to accelerate the spindle to achieve a predetermined first rotational speed; to disengage the drive to coast the spindle to a predetermined second rotational speed; and to engage the drive and inertia friction weld together a second pair of parts;

a logic controller operatively connected to the motion controller, the logic controller being configured: to initiate contact between the first pair of parts and the second pair of parts; and to measure and store data related to the deceleration of the

spindle during the sample inertia friction weld; and

a central processing unit operatively connected to the logic controller, the central processing unit configured: to calculate a sample deceleration profile of the spindle from the data acquired during the formation of a sample weld of the first pair of work parts and to communicate with the motion controller which controls the torque applied to the spindle during formation of a production weld of the second pair of parts so that the spindle deceleration during the formation of the production weld matches the sample deceleration profile of the spindle during the formation of the sample weld and so that the production weld ends in the specified angular orientation of the second pair of parts with respect to each other.

[C37] The weld system of claim 36 wherein the motion controller and the logic controller are configured to disengage the drive from the spindle during formation of the weld of the first pair of parts.

[C38] The weld system of claim 37 wherein the motion controller is configured to maintain the predetermined first rotational speed until a rotary position of the spindle matches a calculated value.